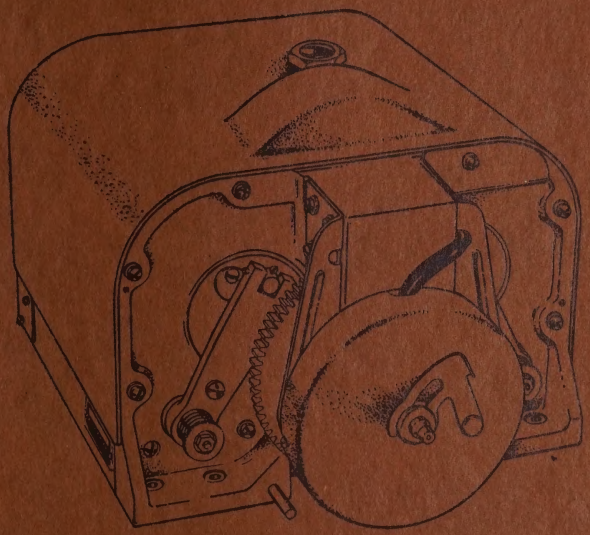
Electronic
C-1 AUTOPILOT
SERVO UNIT

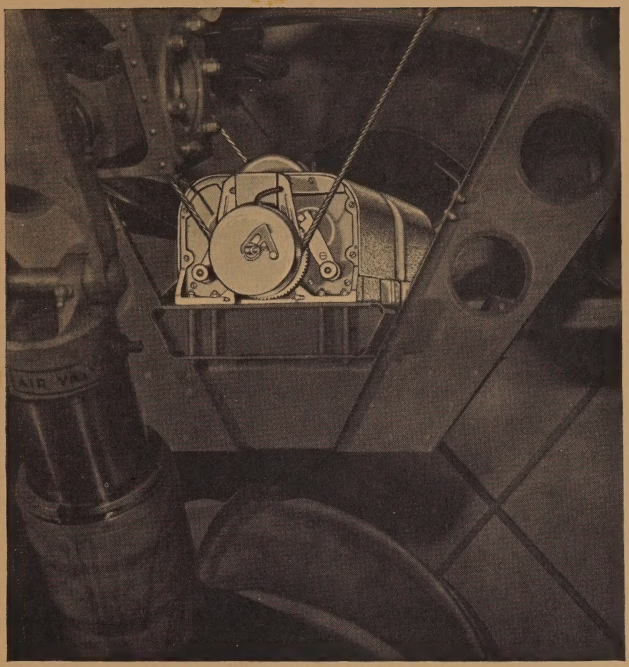
RESTRICTED



Transvision

TECHNICAL PRESENTATION BY JORDANOFF

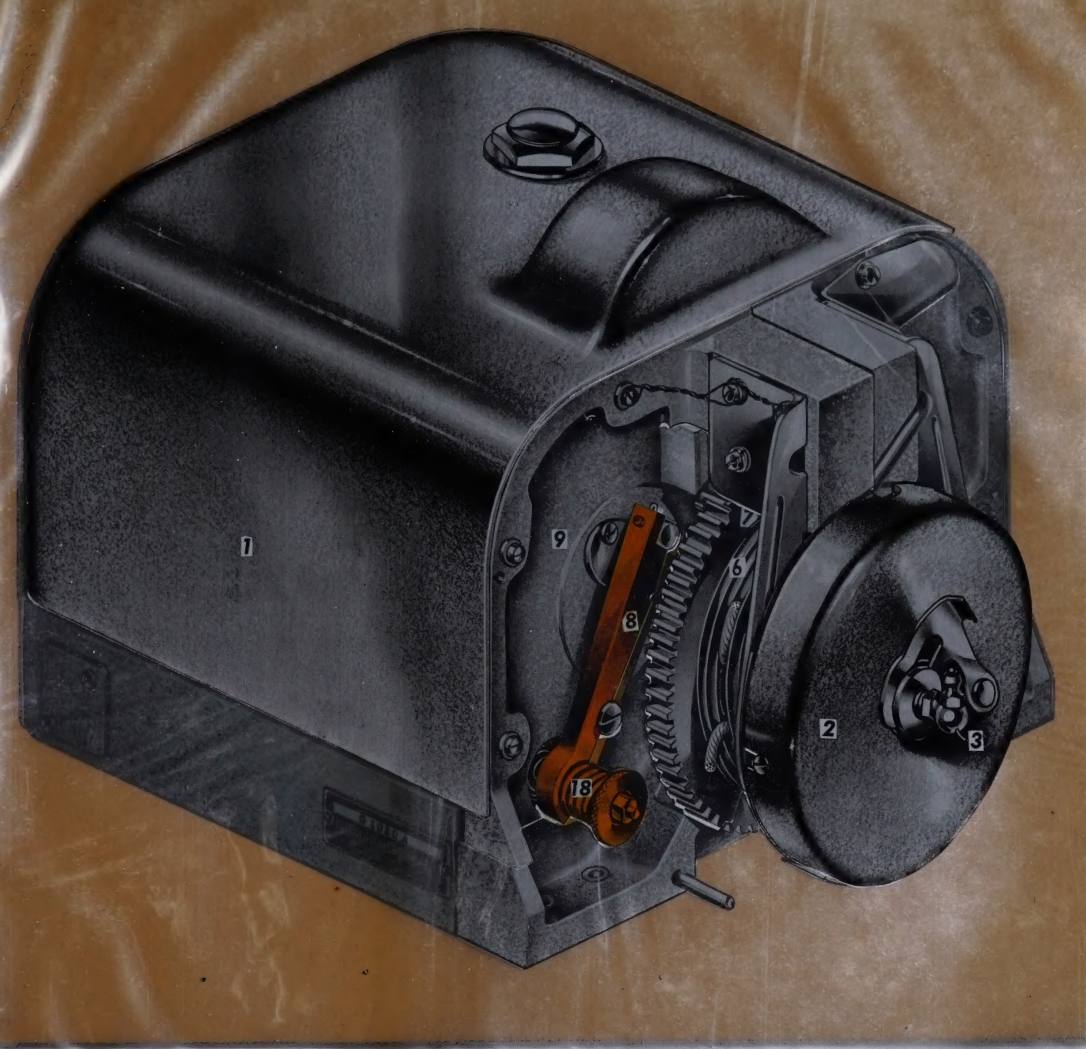
MINNEAPOLIS-HONEYWELL REGULATOR COMPANY
AERONAUTICAL DIVISION
MINNEAPOLIS, MINNESOTA



SERVO UNITS ★ FOR RUDDER AND ELEVATORS ★
INSTALLED IN A FLYING FORTRESS

Servo Unit

Powerful, compact, and efficient . . . the three Servo Units of the C-1 Autopilot system are the electro-mechanical workmen who hold each giant bomber "on the beam." ★ With their instantaneous response, reversible action, and ability to "hold tight" at any position . . . they swiftly and smoothly manipulate the control surfaces of the airplane. ★ Each at its specific station — one for the ailerons, one for the rudder, and one for the elevators — they accurately and dependably obey the commands from the Vertical Flight Gyro, Directional Stabilizer, and the Turn Control to maintain the airplane in correct flight attitude.



Working as a team, and coordinated in their movements by the other instruments of the C-1 Autopilot, the three Servo Units provide the mechanical driving power for operation of the airplane's flight control surfaces.

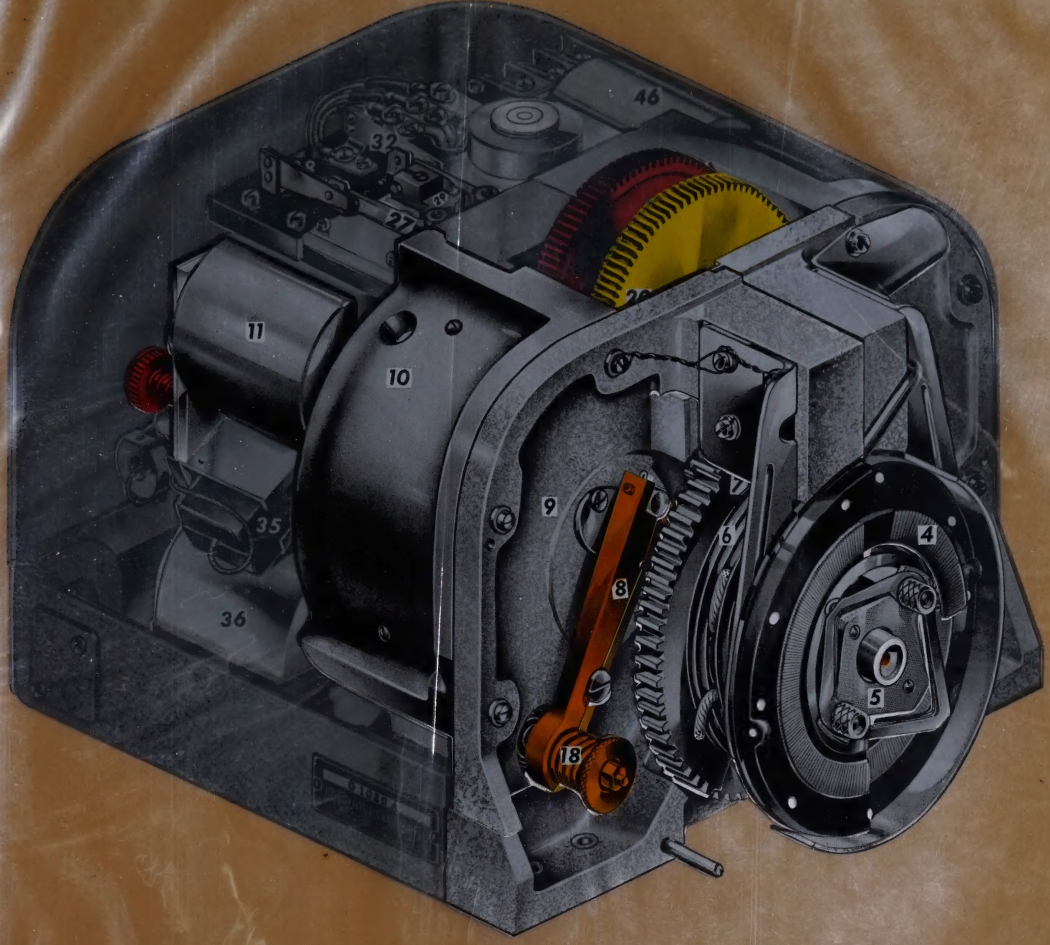
With plenty of power instantly available for operation of the controls at any flying speed, the Servo Units start each control movement rapidly, measure each movement to produce the exact flight correction required, then gradually reduce the speed of control movement as the proper position is reached. Between control movements the Servo Units remain fixed, holding the control surfaces in their proper position.

For a clearer picture of how all this is accomplished, remove the Top Cover (1), the Balance Pot Cover (2), and the Grease Fitting (3) by turning this page.

The illustration on the opposite page reveals some of the Servo Unit's operating mechanisms. Parts of particular interest are the Balance Pot (4), Balance Pot Wiper (5), Cable Drum (6), and Drive Gear (7).

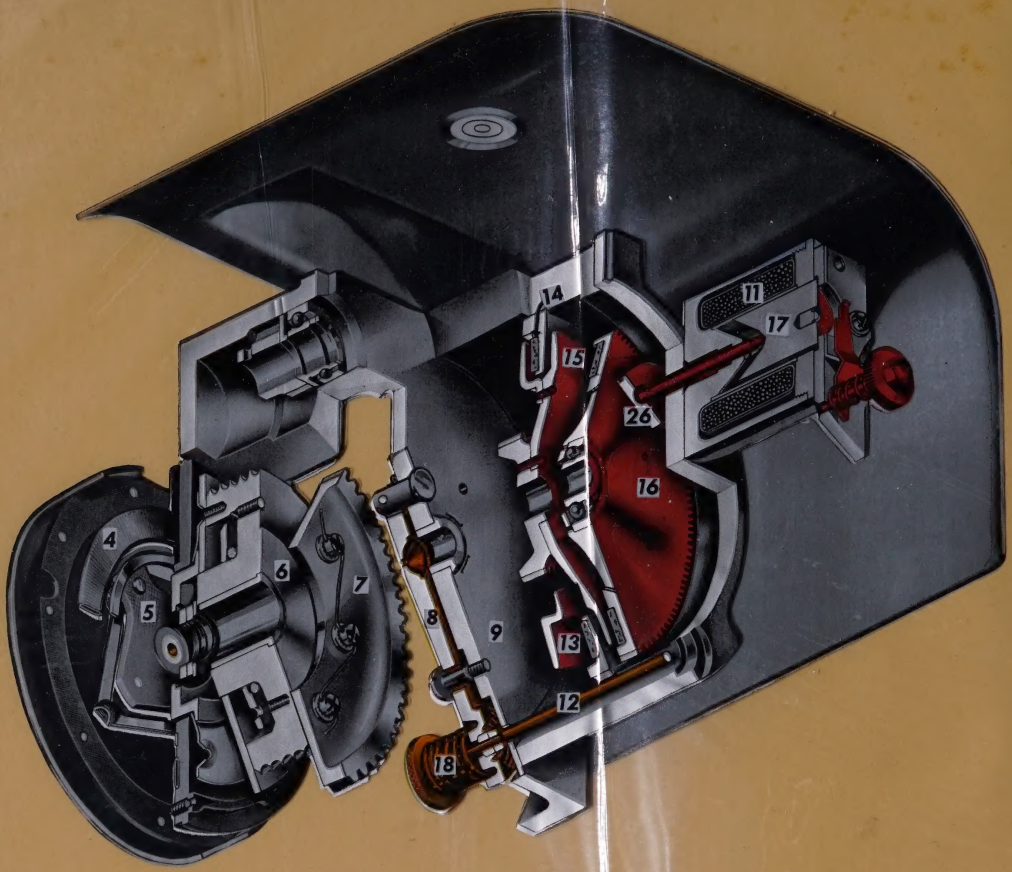
The cable wound on the Cable Drum is connected to the airplane's control system in such a way that rotation of the Cable Drum causes movement of a particular control surface—ailerons, rudder, or elevators.

COLOR NOTE: The parts colored red in these illustrations operate to cause cable drum rotation in one direction, while those colored yellow cause cable drum rotation in the opposite direction. The orange parts apply the force required to "engage" or "disengage" the unit.



The Pot Wiper (5) is fastened to the Cable Drum. The Balance Pot (4), on the other hand, is fastened to the stationary End Plate (9). Therefore, each movement of the Cable Drum is measured electrically by the movement of the wiper across the pot. Other instruments in the system are sensitive to this electrical measurement of the control movement and automatically "turn off" the Servo Unit when the Cable Drum has moved the control surfaces the proper amount.

The important functions of the Brake Arm (8) and the Brake Tension Spring (18), and also of the Operating Solenoid (11), can be more clearly seen when the Servo Frame (10) and the other obstructing parts are sliced away by turning this page.

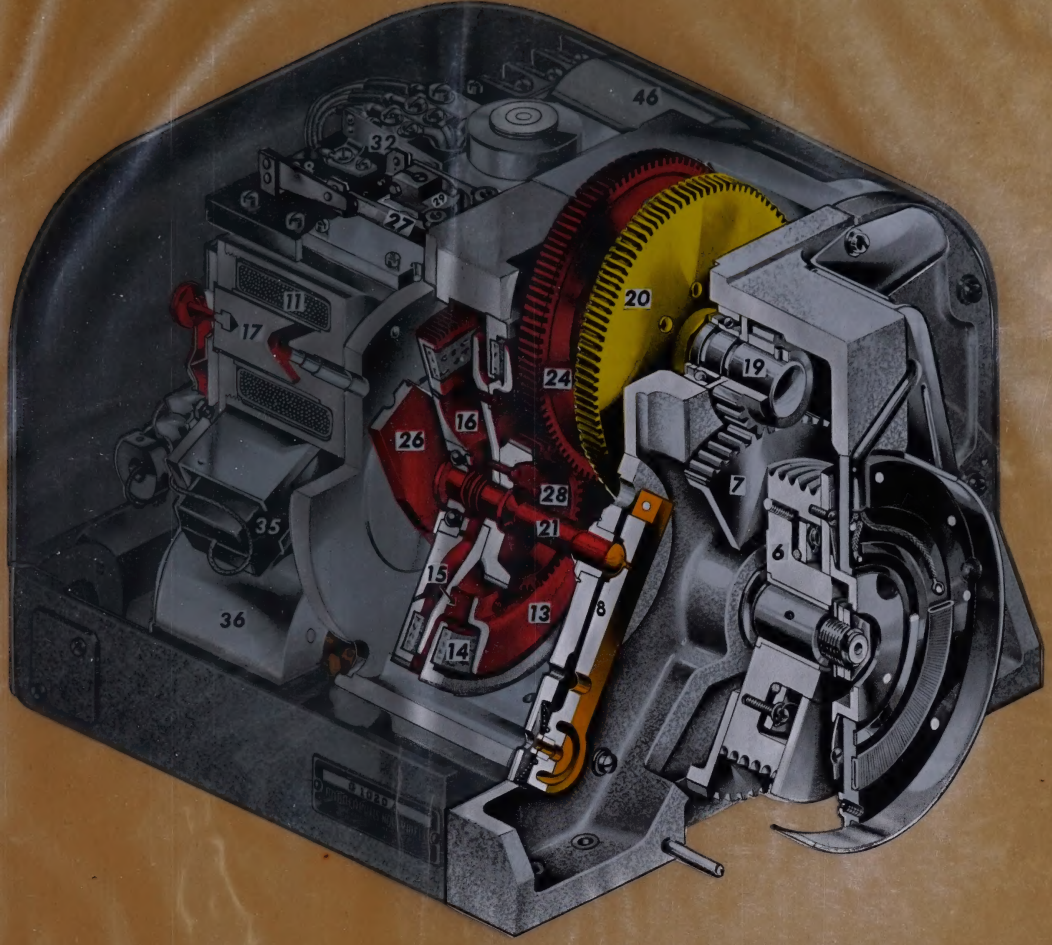


Notice above how the Cable Drum (6) is fastened to its Drive Gear (7); then see on the opposite page how this Drive Gear is turned by the Drive Gear Pinion fastened to the Differential Shaft (19).

Notice also above how the Brake Arm (8) is hinged at its upper end. During Autopilot operation the lower end of the Brake Arm is held in toward the End Plate (9) by the Brake Pull Rod (12), which compresses the Brake Tension Spring (18).

When the Operating Solenoid (11) is energized, its Plunger (17) pushes against the tip of the Clutch Arm (26).

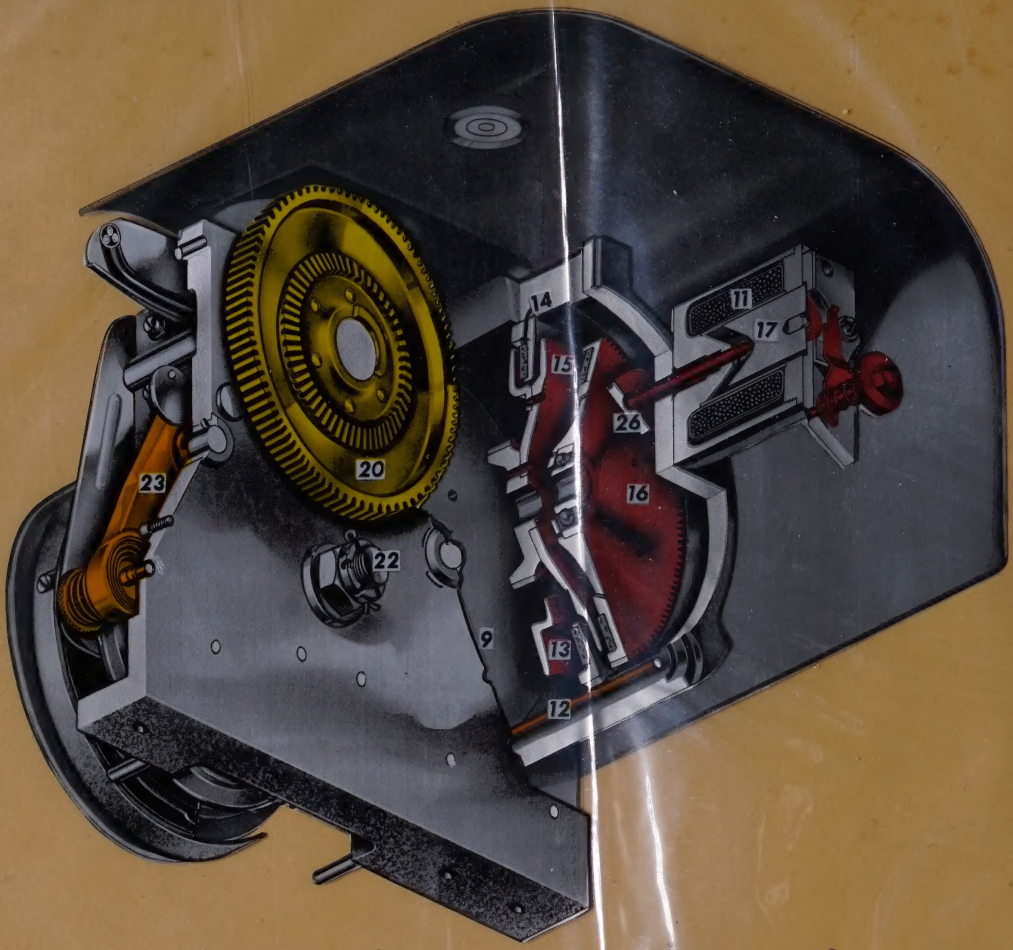
(The operation of parts 13, 14, 15, and 16 is explained on page 7.)



The Differential Shaft (19), which drives the Cable Drum Pinion, passes through the Differential Gear (20) and is fastened to the Differential Crosshead (25), shown on page 7.

Pressure is applied by the Brake Arm (8) against the end of the Operating Shaft (21). A similar Brake Arm on the other side of the Servo Unit is hidden by the Cable Drum and Balance Pot.

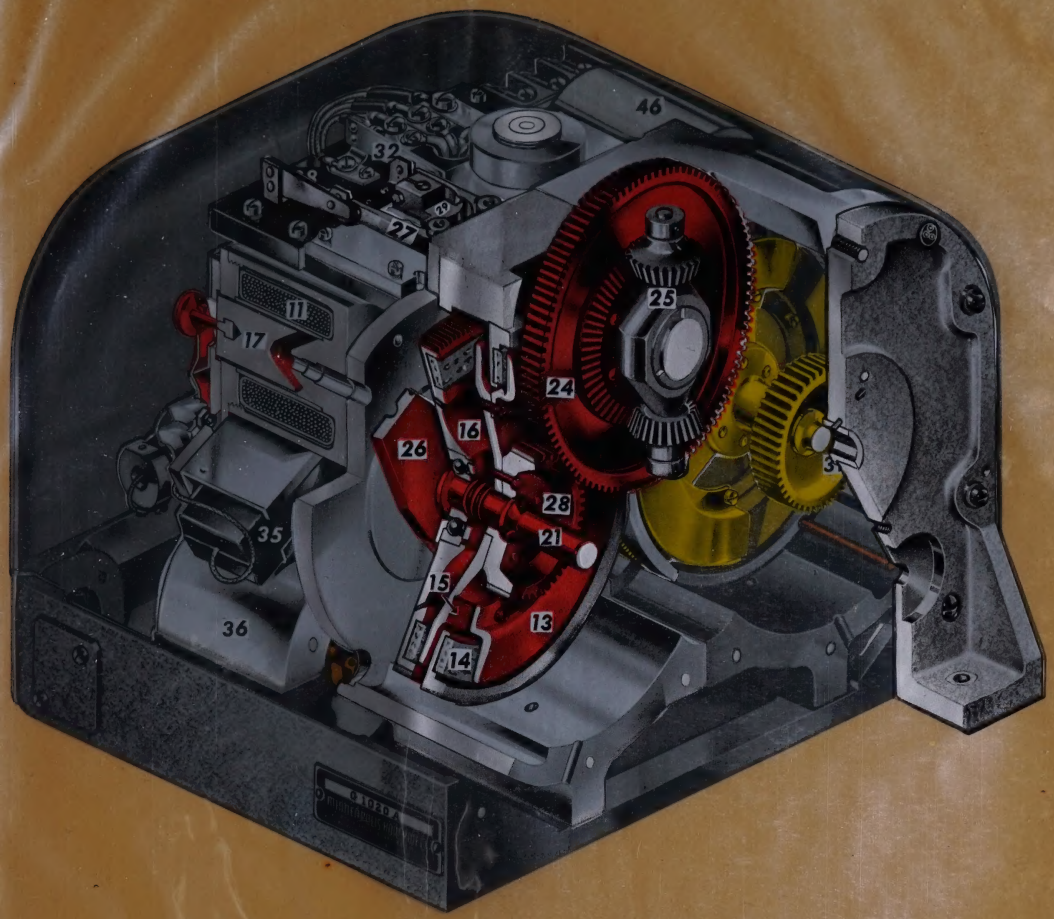
Turning this page will reveal the gear train and related parts which determine the direction of Cable Drum rotation, depending on whether the Operating Solenoid (11) or a similar Operating Solenoid (46) on the other side of the unit is energized (page 13).



Bolt (22), which supports the Cable Drum, is pictured above. The Brake Arm (23) is similar to the Brake Arm already described.

Differential Gear (20) meshes with Operating Shaft Gear (31), shown on page 9, in the same way as Differential Gear (24) meshes with Operating Shaft Gear (28). (Refer to opposite page.) Crosshead (25) lies between the two differential gears. It is therefore held stationary when both gears are stationary, but will rotate when either gear is turned by its Operating Shaft Gear.

Operating Shaft Gear (28) is fastened rigidly to the Clutch Disc (15) and the Brake Disc (13). The whole assembly is mounted securely on the Operating Shaft (21).

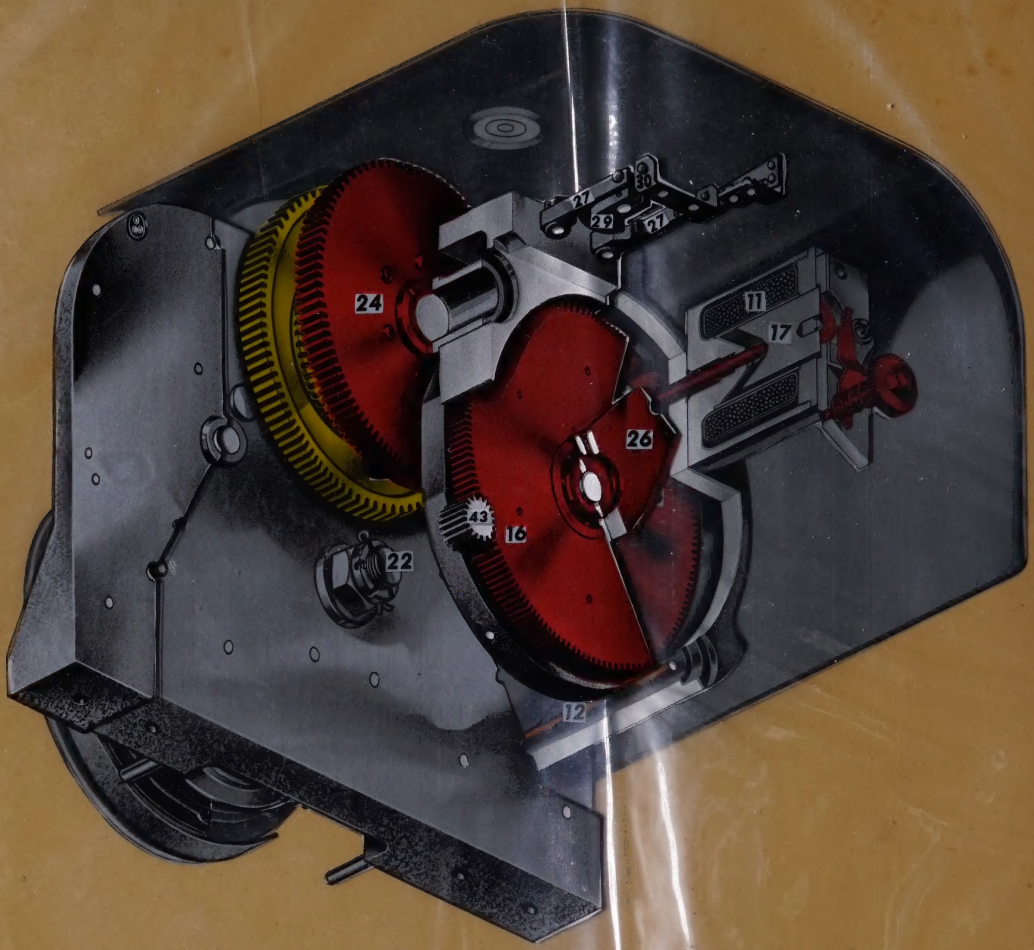


As explained previously, the Brake Arm exerts a constant pressure on the end of the Operating Shaft, which forces Brake Disc (13) against the stationary Cork Surface (14) holding Differential Gear (24) fixed. The other Differential Gear (20) is held fixed in a similar way.

However, when the Operating Solenoid (11) is energized, its Plunger (17), shown on page 4, pushes the Clutch Arm (26) against the rotating Clutch Gear (16), forcing its cork surface against Clutch Disc (15). This force is sufficient to compress the Brake Tension spring and separate the Brake Disc (13) from the Brake Cork (14). Then the Operating Shaft Gear (28) rotates in the same direction as Clutch Gear (16) and drives the Cable Drum through the differential assembly.

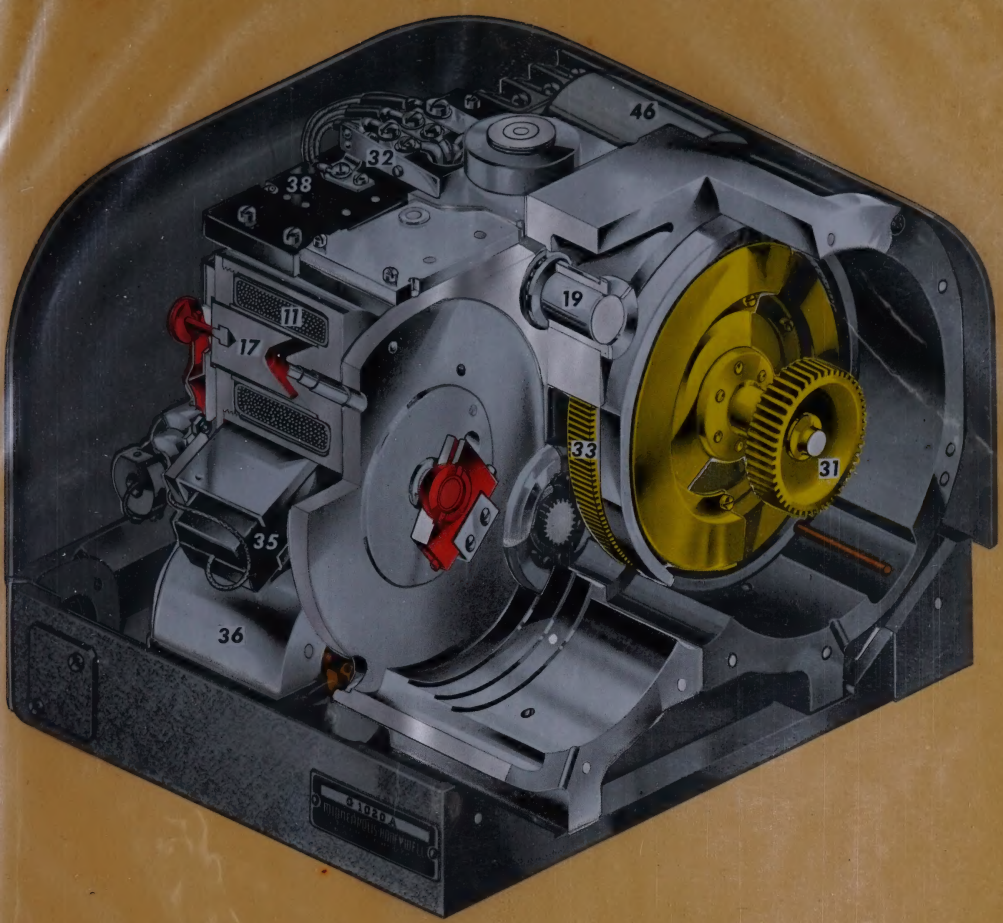
If the other Operating Solenoid (46) had been energized instead, a similar gear train on the other side of the Servo Unit would have produced opposite rotation of the Cable Drum.

Operation of the Limit Cam (29) is explained on the following page.



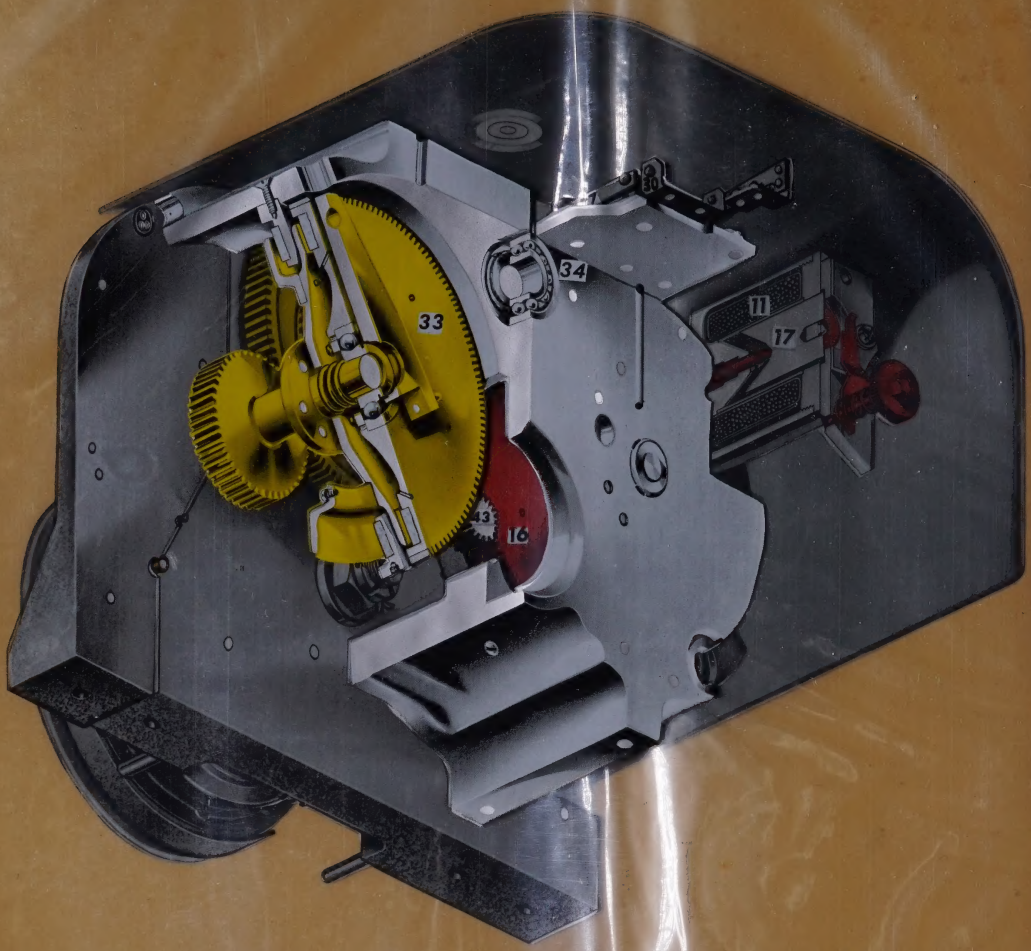
This illustration shows a bottom view of the Limit Cam (29), which lies between two Switch Arms (27) and is fastened to a shaft which is geared to the cable drum (see page 13). When the Limit Cam rotates far enough in either direction to push one of these arms outward against an adjacent Spring Blade (32), shown on the opposite page, the Spring Blade is forced away from the Stationary Contact (30) to open a circuit and cause the Servo Unit to stop its rotation.

Clutch Gear (16) is driven by the Motor Pinion (43).

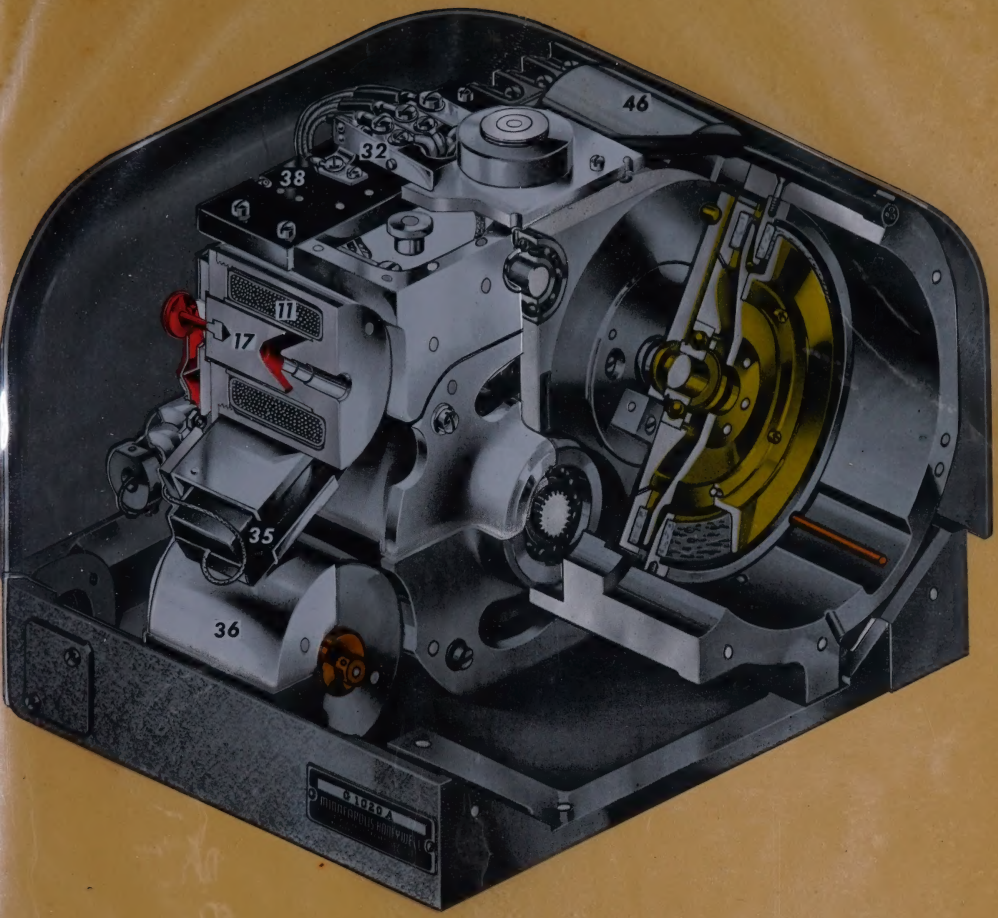


This illustration shows Operating Shaft Gear (31) fastened to its operating shaft and its Clutch-and-Brake Disc Assembly on the opposite side of the Servo Unit.

It also shows a section (19) of the Differential Shaft, which extends all the way from the Cable Drum Drive Pinion (page 5) back to the Limit Switch Drive Worm (page 13).



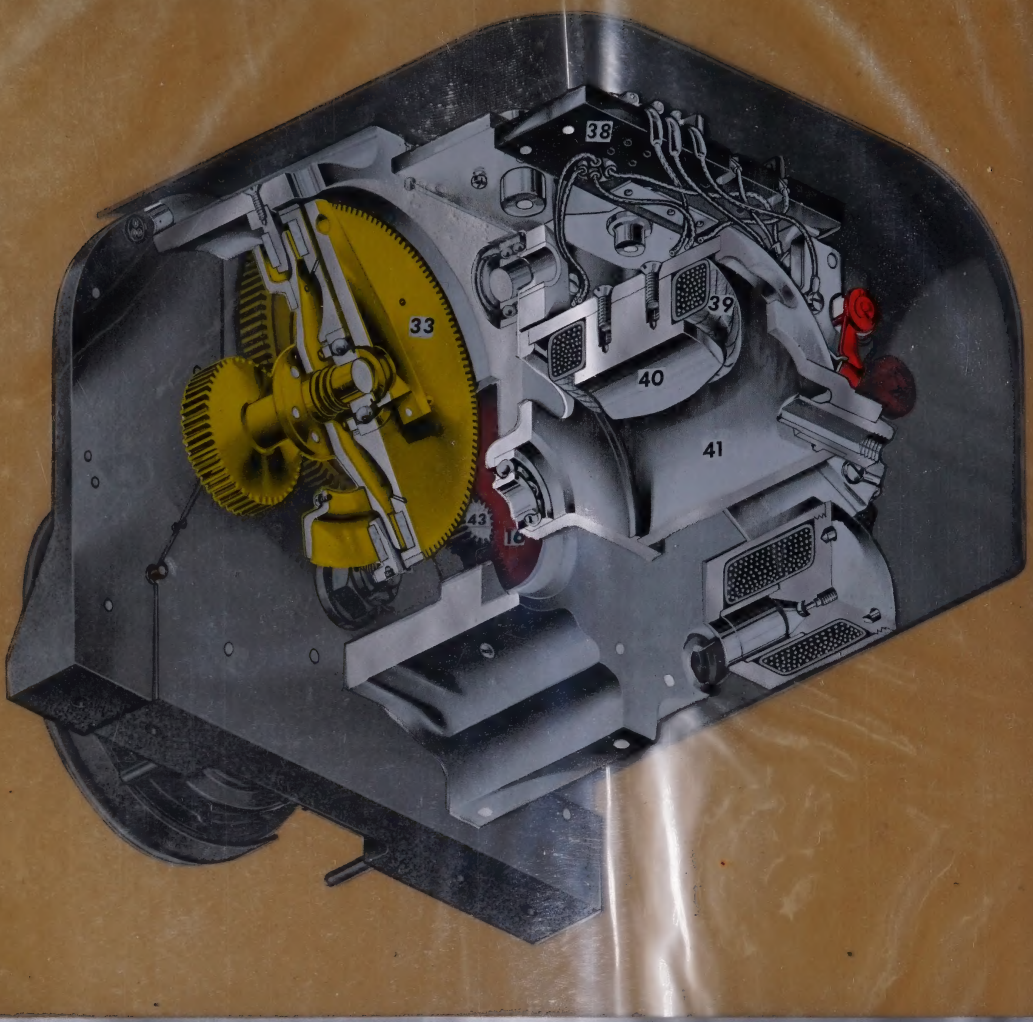
The Clutch Gear (33) shown here meshes with the other Clutch Gear (16) on page 8, which in turn is driven by the Motor Pinion (43). Thus, the two Clutch Gears rotate constantly in opposite directions, and the direction of cable drum rotation is determined by which of these two gears is engaged with its Clutch Disc.



The bakelite Terminal Block (38) provides a convenient place for making the necessary electrical connections.

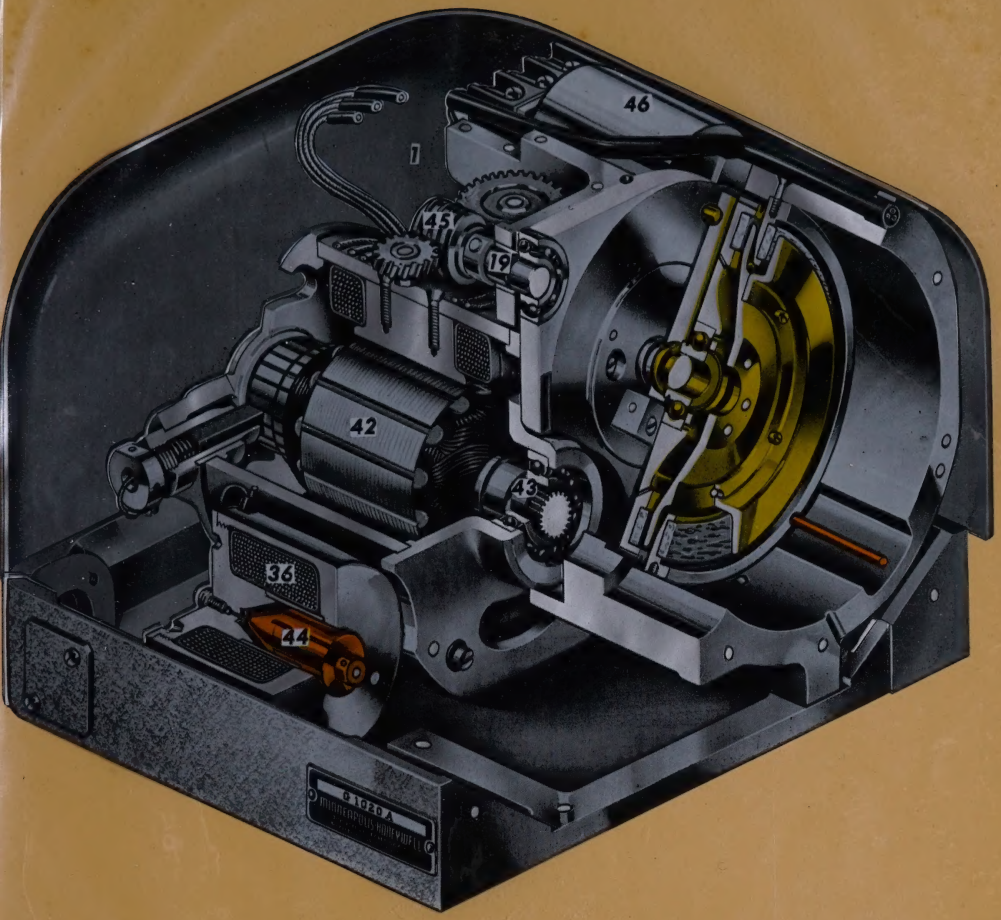
When the Operating Solenoid (11) is energized by the corresponding relay in the Amplifier, its Plunger (17) is forced inward against the Clutch Arm (26). This action engages one set of clutch surfaces, as explained on page 7.

The Condenser (35) is connected in parallel with the Operating Solenoid to minimize radio interference and to reduce arcing at the relay contacts in the Amplifier.



This illustration shows the Servo Motor Field Coil (39) and the Pole Piece (40) as well as the Servo Motor Field Ring (41).

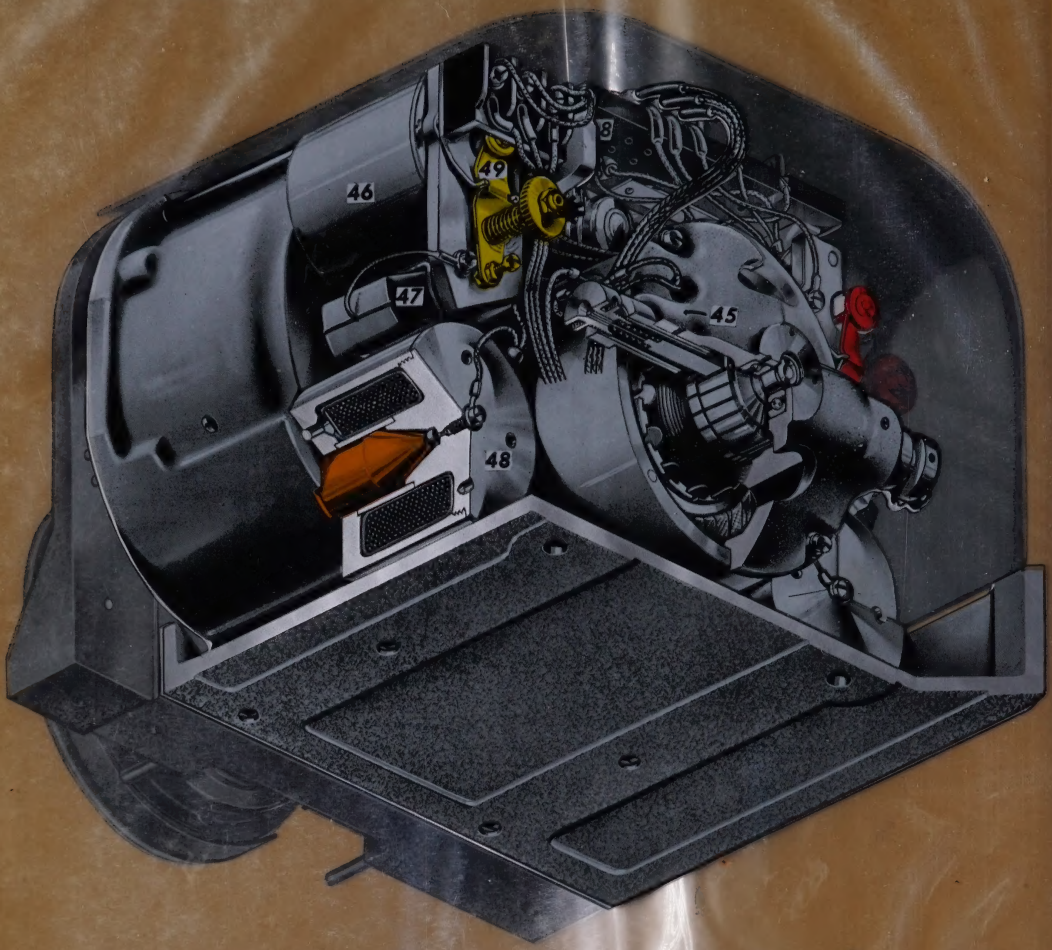
The Servo Motor, which supplies the mechanical power for rotation of the Cable Drum and movement of the airplane's control surfaces, is a shunt-wound 1/20 HP, 26-volt D.C. motor with a speed of 2270 R.P.M. (with no load). Its operation is controlled by the Autopilot Master Switch, and it is therefore running all the time the Autopilot is used.



Shown here are the Servo Motor Armature (42), the Motor Pinion (43), the commutator and its brushes. Notice also the Worm Gear (45) which drives the Limit Switch Pinion.

Both Brake Solenoid (36), and another Brake Solenoid (48) on page 14 are energized by the Servo Unit engaging switch on the Autopilot Control Panel. Thus both Brake Solenoids are energized all the time the Servo Unit is "engaged."

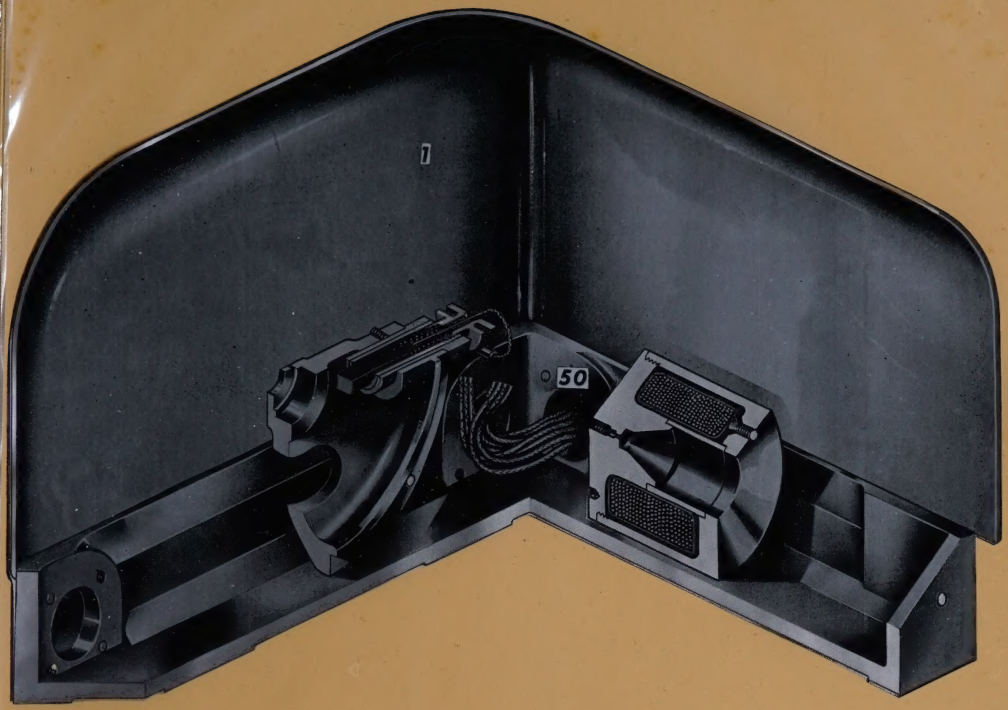
When the Brake Solenoid is energized, its Plunger (44) exerts a pull on the Brake Pull Rod (12) which compresses the Brake Tension Spring (18) and applies pressure through the Brake Arm (8) and Operating Shaft (21) to the brake surfaces. (Refer to pages 4, 5, and 7.)



Illustrated here are the Operating Solenoid (46) and its Condenser (47). When energized, this Operating Solenoid causes opposite rotation of the Cable Drum, as previously explained.

This illustration also shows the Brake Solenoid (48) and its Plunger, which were hidden in previous illustrations.

The spring-loaded Rocker Arm (49) on the back of the Operating Solenoid governs the speed of the plunger travel and thereby regulates the speed of Cable Drum rotation when the Operating Solenoid is energized intermittently. A special control function of the Amplifier produces intermittent operation of the solenoid when the control surface is nearing its desired position to prevent overshooting that position.



The various wires (50), which connect the Servo Unit balance pot, motor, and solenoids to the A-N connector receptacle at the rear of the base, are shown here at the point where they pass through the base casting.

This is a rear view of the Servo Unit, showing the Outlet Box (51) and A-N Receptacle (52). This outlet box may be moved to any of three other locations. (Two of these locations are indicated here by the square cover plates; the third is shown on page 13.)

In a similar way the A-N Receptacle may be fastened to any of the five exposed surfaces of the Outlet Box.

U. S. PATENT NUMBER 2,2
MILPRINT, INC., MILW